Designing the Best Possible Conservation Buffers

Vegetative, or conservation, buffers can serve many different purposes all aimed at the same goal—cleaner soil and water. Clean waterways and healthy soil are goals shared by many, including environmental regulatory agencies. In rural areas, farmers play an integral part in getting to that goal.

Since the beginning of U.S. Department of Agriculture-sponsored agricultural conservation in the 1930s, farmers have focused on how to preserve the environment while raising crops and livestock. Most times, the farmers changed the things they did in their fields to be better conservationists. Now, use of streamside and field-edge buffers gives farmers a set of conservation tools to use outside their fields in the less productive parts of their farms.

Agricultural Research Service scientists in Tifton, Georgia, and scientists at the University of Georgia have conducted studies that examine several different scenarios farmers encounter. Ecologist Richard Lowrance, of the ARS Southeast Watershed Research Unit, and engineer George Vellidis, of the University of Georgia, recently conducted a 9-year study to determine

Restored riparian forest buffers like the one ecologist Richard Lowrance is standing next to provide protection from manure nutrients running off into ponds and the downstream watershed.

PEGGY GREB (K10847-1)

whether restored conservation buffer zones in wetlands next to agricultural fields can reduce the amounts of phosphorus and nitrogen that reach streams that eventually lead to larger surface waters like lakes and rivers. They have found a restored three-zone conservation buffer to be quite effective in removing excess nutrients from water that runs off agricultural fields that have manure applied as a fertilizer.

Buffers, it seems, may well offer assistance to the agricultural community in improving water and soil quality. "Riparian buffer zones are areas of vegetation that act like sponges that take up water and nutrients from the soil," explains Lowrance. "Buffer zones also help reduce soil erosion along downward slopes that is due to rain events or irrigation and can cause surface runoff."

Long-Term Conservation Buffer Research

The buffer system used in the long-term study has three zones. "Zone 3 is a grassy edge that sits next to the field, zone 2 is a managed forest buffer that is situated farther from the field, and zone 1 is a permanent forest along the stream," says Lowrance. To obtain a baseline of runoff amount and content without riparian buffers, before planting, researchers monitored both nutrient levels put on the field as well as nutrient levels leaving the field. In the permanent forest, they planted tulip poplars, green ash, and swamp black gum; then they let native plant species establish among the trees over time. The scientists allowed natural succession to produce the final mix of plants.

For the next 9 years, they monitored amounts of water and concentrations of nutrients (nitrogen and phosphorus) in water entering and leaving the riparian wetland. The streamflow concentrations of nitrogen and phosphorus leaving the conservation wetland buffer were about one-half and one-quarter, respectively, of the incoming concentrations in surface runoff from adjacent fields.

Even though 9 years may seem like a long time for a scientific study, it is a relatively short time compared to a forest's lifespan. "This is a young forest at 9 years old. It would take about 40 years to produce a mature forest," says Lowrance.

Generally, young forests have higher nutrient uptake rates because the plants within them are growing more, while mature forests have prepared the way to create forest soils through leaf litter and shallow roots, which increase biomass on the forest floor. All these factors are keys to reducing the movement of nutrients to surface waters.

"It's important to understand how buffers can be used to help reduce nutrient transport to streams, because of the potential for high loading of nutrients from manure application sites," says Vellidis. "These studies showed that the restored riparian wetland buffer retained or removed at least 60 percent of the nitrogen and 65 percent of the phosphorus that entered from the adjacent manure application site. This is the first time that

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Engineer Andy Knowlton collects water from a farm pond downstream from the restored riparian forest buffer.

a study of a restored riparian buffer has shown that the retention of phosphorus was as high or higher than nitrogen retention."

Surface runoff and subsurface flow of water from farmland on which animal waste has been applied can contribute to significant loading of nutrients to receiving waters unless appropriate management techniques are used. Grass buffer zones or vegetative filter strips have been investigated as a means of reducing nutrient loads in streams.

Though conservation buffers are being used to improve water quality through USDA cost-share programs such as the Conservation Reserve Program, few studies have looked at the effects restored conservation buffers have on water quality. "Most of our management recommendations have been based on mature forest buffers and have focused on nitrogen. Now we know that a restored riparian forest buffer can be just as effective for phosphorus removal," says Lowrance.

The 9-year study was in response to a request made in the late 1980s and early 1990s by USDA's Natural Resources Conservation Service and Forest Service to suggest riparian buffer specifications. At that time, the general recommendation was that natural mature buffers should be used, but USDA needed national specifications based on the best science. The study of restored conservation buffers conducted by Lowrance and Vellidis put the general principles into practice and was the first detailed test of a restored riparian buffer. But Lowrance and Vellidis are not alone—other ARS projects have also been conducted around the country to test buffer zones. And there are other pressures on farmers and their states to reduce nutrients coming from fields and entering streams.

Other Conservation Buffer Research

Another study in Tifton is being conducted by soil scientist Robert Hubbard and animal scientist G.L. Newton of the University of Georgia to evaluate effectiveness of a grass-forest

buffer (zones 3 and 1) treatment system to filter out nutrients from swine lagoon contents sprayed onto fields. Water and soil samples are taken and examined for the amount of phosphorus and nitrogen removed by the system. Nutrient uptake for the grasses is limited, with uptake of nitrogen at almost 45 percent and phosphorus at nearly 20 percent. This research indicates that grass buffers do not work well as a sole buffer against nitrogen and phosphorus runoff but work better when combined with other buffer systems such as forested buffers.

In another study headed by Lowrance and Vellidis, herbicides were examined in a grass-forest buffer system. During this 3-year study, they found that the three-zone riparian buffer was effective at reducing the amounts of two herbicides, atrazine and alachlor, that entered the shallow groundwater and surface runoff. In contrast to the results with nitrogen and phosphorus, the grass filter strip received higher amounts of herbicides and provided a higher rate of removal. So the entire buffer system (grass plus forest) is effective at reducing herbicide concentrations to below detectable levels and in substantially reducing nutrient amounts.

Lowrance and Hubbard conducted another study to determine whether removal of mature trees in a streamside mature forest buffer would limit the buffer's effectiveness at removing nutrients. Again using a three-zone system, Lowrance and Hubbard removed trees that were estimated to be 45-50 years old in the part of the buffer not immediately next to the stream. They found that the buffer's pollution (nitrogen, phosphorus, and pesticides) control functions suffered no harm. The harvested forest grew back quickly, and the forest soil in the study area experienced very little disturbance. This study offers promise that farmers will be able to gain income from the buffers while keeping their buffering capacities at peak levels.

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Technician Chris Clegg prepares samples for nitrogen gas analysis to estimate denitrification rates. During denitrification, microbes remove nitrate from shallow groundwater.

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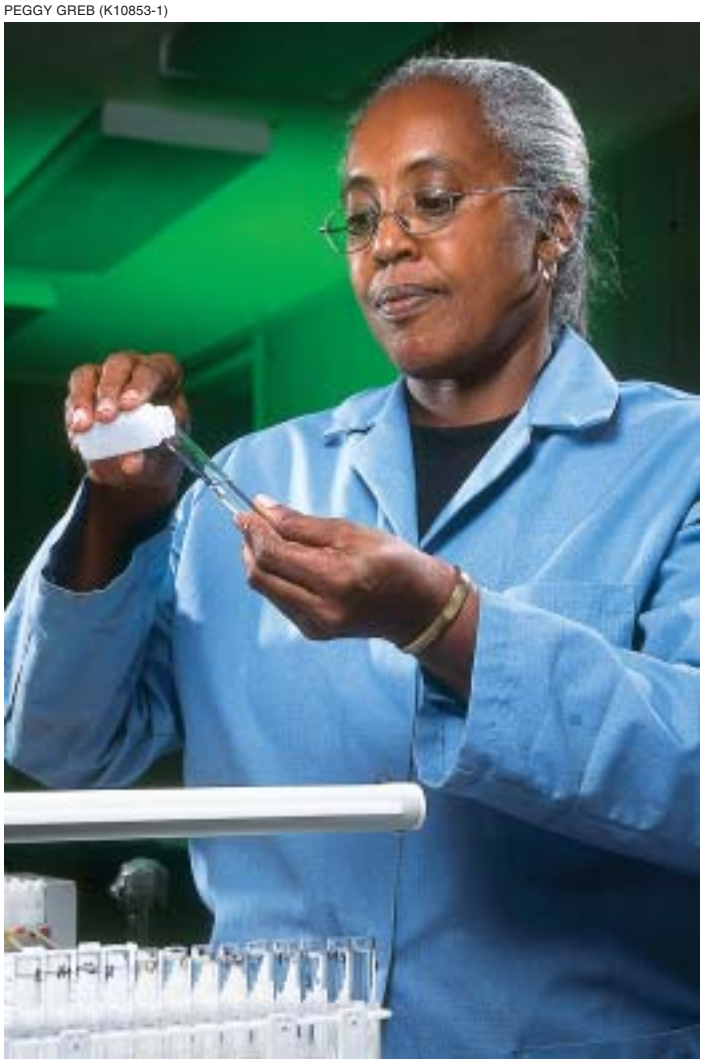

Accurate and precise determinations of nutrient levels in water and soil samples are essential for evaluating buffer effectiveness. Here, chemist Leila Hargett prepares water samples for nutrient analysis by automated colorimetry.

Future Considerations

The U.S. Environmental Protection Agency, through the Federal Water Pollution Control Act Amendments of 1972, mandates development of water quality management plans to control nonpoint-source, or diffuse, pollution from agriculture, including manure application sites. As a result, considerable research has been devoted to this topic. Coastal plain streams in Georgia, Florida, and other states often don't meet water quality standards because of low dissolved oxygen. "This may be due to nutrient enrichment mostly from diffuse sources of nitrogen and phosphorus in these streams," says Lowrance.

According to Lowrance, the buffer research should help. "Ultimately, this research should aid growers in developing a way to lower nutrients that make it to streams and waterways."

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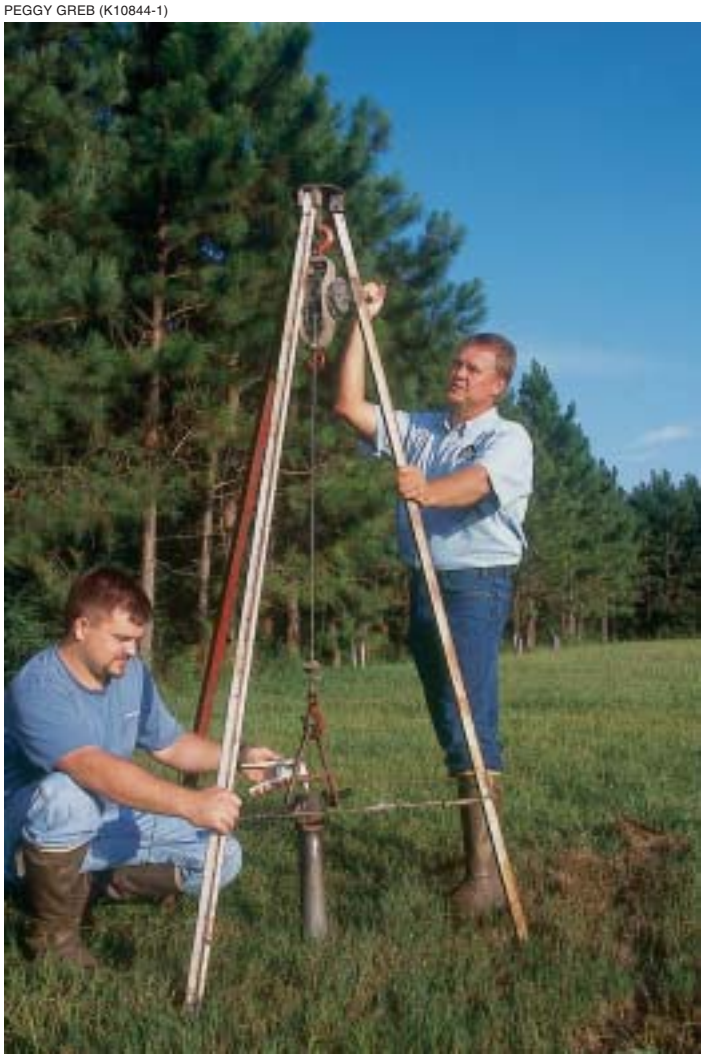

Engineer Andy Knowlton (left) and technician Rodney Hill take a deep soil sample from the edge of a buffer system to estimate denitrification rates in the soil.

PEGGY GREB (K10850-1)

Paige Gay, a University of Florida Ph.D. candidate, collects a runoff sample from a LowImpact Flow Event (LIFE) sampler. The restored buffer she is testing removes sediment and chemicals from surface runoff.

"Buffer zones are not a magic bullet, but a system to mitigate nutrient flow to soil and water," says Vellidis. "The most important aspect of this research is that the restored buffer has been studied for a relatively long time, and the studies have revealed that there is a large nutrient retention."

Through the years, it became clear that trees or forests must be part of the conservation buffer system if nitrogen and phosphorus and other pollutants are going to be removed. "For the Southeast, we are now suggesting that restored conservation buffers that include a managed forest buffer can actually outperform a mature forest," says Lowrance.

The next step for Lowrance and Vellidis's study of restored conservation buffers is to assess an entire watershed. According to Lowrance, such a study would require intense collaboration between state government, farmers, and scientists. "To ideally study a 5,000-acre watershed, scientists would have to collect all the data about the ecosystem for 5 years, then put in a wide range of buffers. It would then take 20 to 30 years to monitor and analyze the relationship between the buffers and runoff," says Lowrance.—By **Sharon Durham,** ARS.

This research is part of Water Quality and Management, an ARS National Program (#201) described on the World Wide Web at www.nps.ars.usda.gov.

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